

time of year when I made my observations. It also probably reduces the diversity of species and changes the habitat to suit ground-feeding birds, such as the Pied Wheatear and Brown Rock Chat, at the expense of Wren-Warblers and other species which favour dense vegetation.

The change from a luxuriant seasonal development of ground vegetation, as seen in the enclosures, to a very small amount of ground cover, as seen outside the enclosures, is one that must have taken place over large areas of India within the last millenium in response to the gradual increase in the human population and its domestic flocks. We can probably assume that this has led to a corresponding change in bird populations. For migrants the impact of these changes will also have been

experienced on their breeding grounds, where the size of breeding populations may have altered in response to changes in the availability of wintering habitat.

Because the well-vegetated enclosures appear to support a greater diversity of birds than unenclosed areas we can probably assume that an increase in grazing pressure has been associated with a general decline in the diversity of birds in areas supporting the type of semi-arid ecosystem characteristic of north-western and central India. I have already suggested elsewhere that the distribution of rare and local passerine birds in different ecogeographical regions of India and Pakistan provides evidence that such a process has been at work for some time (Gaston 1984).

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19. SIGNIFICANCE OF RESIDUAL EGG-FLUID TO HATCHING PATTERNS IN THE GHARIAL (*GAVIALIS GANGETICUS*) AND EMYDID FRESHWATER TURTLES (REPTILIA; CROCODILIA AND CHELONIA)

(With a text-figure)

INTRODUCTION

Reptiles were successful as land vertebrates over the amphibians mainly due to evolution

of the egg with extraembryonic fluid. Therefore, conservation and maintenance of this fluid all through the development from egg-laying to hatching is of high significance to a species.

The significance of retention or otherwise of the egg-fluid at hatching in two primitive groups of reptiles — the gharial and the emydid turtles — are discussed in this work.

MATERIALS AND METHODS

The interpretations presented in the following are based on extensive observations carried out on hatching patterns of the gharial and turtles in the wild and in captivity (simulated hatchery). Captive observations were made at the Gharial Research and Conservation Unit, Tikkerpada, Orissa and the Gharial rearing project at Deori, Madhya Pradesh, and observations in the wild were carried out in the National Chambal Sanctuary and Satkosha Gorge Sanctuary.

OBSERVATIONS

1. Gharial eggs weigh approximately 157 g and increase to 200 g before hatching while the eggs of the emydid turtles that were studied weigh 57.42 ± 0.9 g (*Kachuga kachuga*), 44.21 ± 5.23 g (*Kachuga dhongoka*) and 21.40 ± 1.056 g (*Kachuga tentoria circumdata*), and do not show any appreciable change in the weight towards end of incubation.

2. Full-term developed and newly emerged hatchlings of *G. gangeticus*, *K. kachuga*, *K. dhongoka* and *K. t. circumdata* weigh 75.3 ± 5.4 g, 29.85 ± 1.732 g, 23.42 ± 6.873 g and 11.91 ± 1.677 g respectively.

3. The difference in the pre-hatching egg weight and the hatchling weight are due to

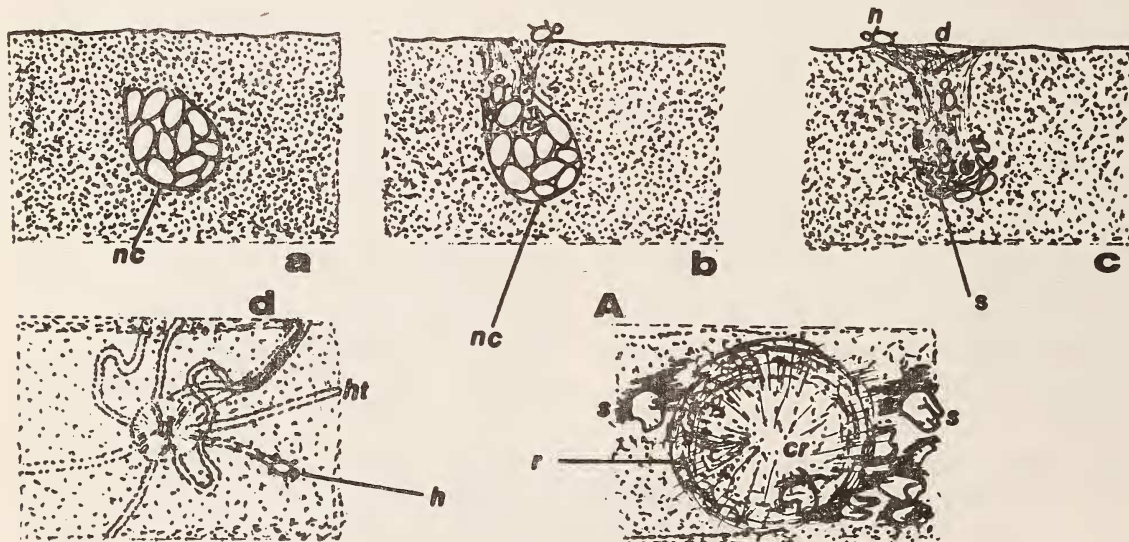


Fig. 1. (a-c): Diagrammatic cross section view of a large emydid turtle (e.g. *K. kachuga*) nest chamber (nc) with sequences of hatching showing formation of surface depression (d) as the hatchlings (h) emerge and empty eggs (s) crumple inside the nest chamber. (1d): surface view of a hatched nest showing tracks (ht) formed by hatchlings (h) as these leave through the nest depression (d). (1A): Surface view of a hatched-out gharial nest showing the crater (cr) and its rim (r) formed after hatching. (s) empty shells that form visual markings.

the weight of shell, shell membrane and residual egg fluid. The residual egg-fluid is over 75 g in the case of gharial while is evident as only traces of 'moisture' in the turtles. Therefore, while turtles hatch dry and neat, the gharial hatch completely wet with considerable amount of egg-fluid.

4. Turtles hatch themselves, without any parental aid. They use the egg caruncle to rupture the shell membrane and then by tearing the membrane with front limbs 'walk-out' of the egg to the surface of the nest (Fig. 1). During this process the egg shells crumple inside the nest chamber and a depression appears on the ground above due to filling in with sand in the space just vacated by the hatchlings.

5. Mother gharial normally responds to the call of the hatchlings during her visits to the nest (Singh and Bustard 1977) and exhumes the nest in order to release out the young ones. During hatching, as the shell flakes off automatically a gharial uses its egg-tooth to rupture the shell membrane (Singh 1975) and then 'wriggles-out' of the egg. The empty eggs, now represented by the cup-like thick shell membrane is made heavy by sand sticking and filling wherever the residual fluid is present. Such heavy empty eggs remain scattered at the hatching site often leading down to the water and are visible from a distance. Some of these eggs also remain covered under exhumed sand of the nest at depths varying upto 30 cm. Signs of hatching can be seen until after a month or the advent of monsoon floods.

DISCUSSION

Based on observations presented in this note, at the time of hatching the gharial still has about 37% (75 g out of 200 g) extra-

embryonic fluid unutilised while in the Emydid turtles the egg is almost dry.

Significance: 'Dry-hatching' vs. 'Wet-hatching' —

In the turtles under discussion, where the mother does not have any role in hatching or thereafter, 'dry hatching' is necessary. With this there is no clogging of the nest chamber and all the hatchlings walk out of the nest leaving behind the empty eggs in the nest chamber below surface.

Contrary to the above, in the gharial the residual egg-fluid plays three roles. First, it maintains a turgor pressure (Singh 1979) which helps in proper puncturing of shell membrane (Singh 1975). Second, with the rupture of the shell membrane the slimy fluid helps the hatchling wriggle and slip out of the egg — its legs are far behind and the hatchling cannot use them to open the shell membrane unlike the turtles. Third, because of sand filling into the empty egg (shell membrane pocket) and making it heavy these empty eggs remain at the nesting site for over a month. Even when the empty eggs at the surface are blown off by wind those which were buried earlier get exposed. These white empty eggs act as visual marking — both for the hatchlings and the mother. The hatchlings remain grouped just down the bank where empty shells are lying and the mother appears near such groups of hatchlings. Therefore, these visual markings by empty shells at the hatching site increases the accomplishment of parental behaviour and the survival value of the hatchlings. It is not known, how in the turtles, in the absence of any parental attendance, nature supports hatchling survival.

To conclude, since residual egg-fluid does not have any role in the hatching and subsequent survival of Emydid turtle hatchlings the

fluid is completely utilised thereby, simultaneously, negating any possible clogging of 'nest-crater' coming on the way in hatching of young ones from the bottom of the nest chamber. In the gharial upto approx. 37% of the total egg weight remain as residual egg-fluid which have a three-fold function, maintaining pressure inside the egg, providing a slimy medium for hatching and holding empty eggs at the hatching site as visual markers —, that increase the survival value of hatchlings. The

retention of fluid for hatching may be considered as an advanced stage in evolution of gharial over the Emydids.

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20. THE DISTRIBUTION AND POPULATION OF CROCODILES IN THE PROVINCES OF SIND AND BALUCHISTAN (PAKISTAN)

In the Indian subcontinent, crocodiles have been plentiful in the past. Even gharial, which is quite uncommon these days, had previously good populations. According to Adams (1967), quoted by Whitaker and Daniel (1978), "Gavial abounds in all the great rivers of North India — 10 or 20 may be seen together". Their range extended throughout the Gangetic system, west to Pakistan and north east to Brahmaputra. Similarly, marsh crocodiles were also abundant. Smith (1931) pointed out that Muggar were once extremely common in the former range from river Dasht

in the extreme west of Pakistan to Assam in North Eastern India and over most of the Peninsula and Sri Lanka. According to Daniel (1976) marsh crocodile is still wide spread in India occurring in almost all the areas of its known distribution; the gharial however remains the most endangered crocodilian of the sub-continent.

Although marsh crocodiles, being better adaptable are still reported to occur in patches in some of their former habitats in Sind and Baluchistan (Khan and Mirza 1976, Khan and Malik, per. comm.), the last available field